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PROMOTING THE NATIONAL DEFENSE BY AUTHORIZING THE CONSTRUCTION OF AERONAUTICAL RESEARCH FACILITIES BY THE NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS NECESSARY TO THE EFFECTIVE PROSECUTION OF AERONAUTICAL RESEARCH

MAY 1, 1952.—Ordered to be printed

Mr. KNOWLAND, from the Committee on Armed Services, submitted the following

REPORT

[To accompany H. R. 6336]

The Committee on Armed Services, to whom was referred the bill (H. R. 6336), to promote the national defense by authorizing the construction of aeronautical research facilities by the National Advisory Committee for Aeronautics necessary to the effective prosecution of aeronautical research, having considered the same, report favorably thereon with an amendment, and recommend that the bill do pass.

PURPOSE OF THE BILL

The purpose of the bill is to provide the National Advisory Committee for Aeronautics with the necessary authorization to enable it to carry out its construction program contemplated for fiscal year 1953.

The bill would authorize the appropriation of a total of $19.7 million, of which approximately $18 million is for technical facilities and the remainder is for the housing of those facilities.

AMENDMENT TO THE BILL

The committee recommends that section 3 of the bill be amended to read as follows:

SEC. 3. There is hereby authorized to be appropriated not to exceed $19,700,000 to accomplish the purposes of this Act.

The original text of section 3 of the bill did not specify a dollar total which was to be authorized by the bill. The committee feels that the limiting of the appropriation authority to $19.7 million—total amount of the construction to be authorized—was more nearly in accord with the purpose of the bill.

Explanation of the Bill

National Advisory Committee for Aeronautics

This Committee was originally authorized by the act of March 3, 1915. Its organization and functions were brought up to date by the act of May 25, 1948.

The Committee is composed of not to exceed 17 members, all appointed by the President and all serving as such without compensation. The membership of the Committee includes representatives from the Air Force, the Navy, Civil Aeronautics Authority, the Smithsonian Institution, the United States Weather Bureau, National Bureau of Standards, Research and Development Board and not more than seven other members selected from persons "acquainted with the needs of aeronautical science or skilled in aeronautical engineering or its allied sciences."

The general purposes of the Committee are indicated below:

Coordinate the research needs of aviation, civil and military.

Prevent duplication in the field of aeronautical research.

Conduct, under unified control of the Committee, scientific aeronautical research, including:

(*a*) Special investigations in the nature of applied research on problems submitted by the Air Force and Navy for immediate improvement in performance of military and naval aircraft.

(*b*) Fundamental researches instituted by the Committee on its own initiative or authorized upon request of the Air Force, Navy, or Civil Aeronautics Authority to increase speed, safety, and economy of operation of aircraft, military and civil.

Advise the Departments of the Air Force and Navy, the Civil Aeronautics Authority, and the aviation industry as to the latest research information.

Consider merits of aeronautical inventions submitted by the public to any agency of the Government.

On request of the President, the Congress, or any executive agency, to advise upon any special problem in aeronautics which may be referred to it.

Specific authority to undertake construction

Subsection 1 (b) of the act of August 8, 1950, gives to the Committee its basic authority to undertake additional construction. This subsection is the one referred to in the first sentence of the bill and authorizes the Committee:

(b) to acquire additional land for, *undertake additional construction at, and purchase and install additional equipment for,* existing laboratories and research stations under its direction;

General description of the construction authorized by the bill

The construction to be authorized by the bill is summarized below. The general description of the four projects included in the summary is shown immediately following the table:

Summary

Langley Laboratory:	
Conversion of the 19-foot pressure tunnel for dynamic model testing	$8, 955, 000
High-temperature structural research laboratory	4, 153, 000
Lewis Laboratory:	
High-pressure air supply and distribution system	1, 642, 000
Expansion of air facilities for full-scale jet engine research	4, 950, 000
Total authorized by the bill	19, 700, 000

The basic purpose of the conversion of the 19-foot pressure tunnel at the Langley Laboratory is to permit a closer study of the effect of gust loads by utilization of dynamic models. The research contemplated will require the installation of a transsonic nozzle and test section to replace the existing subsonic section.

The high-temperature structural research laboratory is for the study of the physical changes which occur in structural materials as a result of heat generated by supersonic speeds.

The expansion of the air facilities for full-scale jet-engine research at the Lewis Laboratory are necessary to keep pace with the increasing power and thrust generated by engines of this type. The changes in the laboratory combustion air supply and distribution system are needed so as to make available combustion air pressures at a higher gage and in quantities sufficient for full-scale engine research.

The construction outlined generally by the foregoing comments is of a highly technical nature and is discussed in greater detail elsewhere in this report.

Coordination among research programs

The committee examined in particular detail the degree of coordination among aeronautical research programs which has been effected among the various agencies so as to insure against waste and duplication.

The committee was informed by the expert witnesses who appeared at the hearing that the construction authorized by the bill in no sense duplicates facilities which are now available elsewhere. Further, these facilities have been decided upon after painstaking and detailed consultation with other agencies having responsibility in this field and represent the requirements of a unified and coordinated program.

Interproject transfers

The authority proposed by section 2 of the bill for the making of interproject transfers up to 10 percentum of the authorized amount is identical with the authority contained in section 503 of the current military and naval construction authorizations contained in the act of September 28, 1951 (Public Law 151, 82d Cong.).

Recommendations of the Departments

The proposed legislation is recommended by the National Advisory Committee for Aeronautics and has received the approval of the

Bureau of the Budget, as is evidenced by the letter of the executive secretary of NACA, which letter is hereto attached and made a part of this report.

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS,
Washington 25, D. C., January 21, 1952.

Hon. SAM RAYBURN,
Speaker of the House of Representatives,
Washington, D. C.

DEAR MR. SPEAKER: There is submitted herewith a draft of proposed legislation to promote the national defense by authorizing the construction of aeronautical research facilities by the National Advisory Committee for Aeronautics necessary to the effective prosecution of aeronautical research.

The purpose of the proposed legislation is to provide legislative authorization for the Committee's 1953 construction program as approved by the Bureau of the Budget for inclusion in the President's budget for the fiscal year 1953.

The proposed legislation has received the approval of the Director of the Bureau of the Budget, who has advised the Committee that there would be no objection to its submission to the Congress.

It is respectfully requested that the proposed legislation submitted herewith be introduced in the House of Representatives and be considered for enactment by the Eighty-second Congress.

Very truly yours,

J. F. VICTORY, *Executive Secretary.*

DETAILED DESCRIPTION OF THE CONSTRUCTION AUTHORIZED BY THE BILL

LANGLEY AERONAUTICAL LABORATORY

Conversion of the 19-foot pressure tunnel for dynamic model testing

Major alterations to the 19-foot pressure tunnel are required for the purpose of increasing the range of speeds and other experimental conditions which may be reproduced in the wind tunnel. The alterations will include replacing the present drive motor with one of greater power installed in an external motor housing. Structural modifications will be made to the tunnel to enable it to operate under a vacuum. Freon-handling equipment will be installed so that the tunnel may be operated with an atmosphere of either Freon or air. A transonic nozzle and test section will be installed to replace the existing subsonic test section. New model supports will be installed for use at transonic speeds. A cooling system will be installed to provide cooling water for the tunnel and for the Freon equipment. An equipment building will be constructed to house the new equipment.

Among the most difficult problems arising from the high speeds of current and future flight are those relating to the structural integrity and aerodynamic stability of the aircraft. Interactions between the complex high-speed airflows, the inertia of the structural and other masses, and the elastic or springlike properties of the aircraft structure and control systems may cause any or all of several serious conditions of vibration or distortion of the machine. In fact, such vibrations and distortions are very likely to occur unless they are prevented by the most careful design.

These conditions of vibration and distortion have heretofore been placed in several categories called flutter, buffeting, and aeroelasticity. Attempts to solve the problems of design falling in these categories have been made as though each problem were a separate one that pertained only to one or a limited number of components of the air-

craft. This method of attack has been forced in part by human inability to grasp the complexities of the over-all behavior of the complete aircraft, and in part by the lack of test facilities in which the over-all behavior can be directly determined by experiment on complete models. Even when attempts are made to solve limited parts of the complete behavior of the machine, the problems sometimes are so complex that they cannot even be formulated, let alone solved theoretically, and available test equipment has been found to be inadequate in several important respects.

For these reasons it is essential that experimental research be conducted on complete models in an appropriately devised wind tunnel to determine the dynamic behavior of aircraft as a whole. The models must have freedom of motion and they must possess mass distribution, elastic characteristics, and details, such as control surfaces, which are representative of the complete aircraft. The laws of similarity are such that small dynamic models of full-scale machines are extremely light and fragile; the necessary characteristics cannot, therefore, be built into small models.

The wind-tunnel requirements for dynamic tests of such models are, in combination, unique. The tunnel test section must be large in order that models of adequate size may be tested with sufficient clearance between the wing tips and the tunnel walls to provide freedom for motion. The tunnel must be capable of operating at least through the transonic speed range. Variable density of the test medium must be provided so that altitude effects may be represented. In addition to air, it is necessary that a gas having special characteristics be used as a test medium in order to obtain dynamic similarity between a model and its full-scale prototype. Such a gas, known as Freon 12, is available, and with this gas one-fifth-scale models can be tested at the same Mach number as the prototype while retaining dynamic similarity in other respects as well. By using both air and Freon as test media, it is possible to segregate the individual effects of airspeed, altitude, Mach number and Reynolds number; it is also possible thereby to obtain dynamic similarity with full-scale aircraft over a range of simulated flight conditions. Because the speed of sound in Freon is much less than that in air, use of Freon also permits the attainment of transonic Mach numbers at much lower speeds and with much less power than when air alone is used.

A study of the tunnel requirements for testing dynamically scaled models of all full-scale prototypes likely to be of interest indicated the technical desirability of building a very large high-speed tunnel. If, however, the size is predicated for reasons of economy on minimum practicable model size of the larger prototypes, a tunnel test section diameter of only about 20 feet is indicated. This size permits use of models of 12-foot span with sufficient clearance for freedom of motion, and also permits conversion of an existing tunnel for dynamic testing (thus avoiding the building of a new tunnel) while at the same time extending its utility for purely aerodynamic testing.

The 19-foot pressure tunnel, converted as proposed, meets the unique minimum requirements for the investigation of flutter, buffeting and other dynamic and static problems of aeroelasticity on complete dynamically scaled models. The changes to the tunnel structure and

drive system would make it possible to obtain high speeds, and by operating at various densities it would also be possible to simulate operation at a wide range of flight altitudes. Use of Freon would make it possible to obtain dynamic similarity between the model and the full-scale aircraft, and would also permit the attainment of high Mach number at lower test speeds and with much less power than if only air were used.

Cost estimate

Electrical drive:		
Drive motor, control, and cooling system	$2, 185, 000	
Power transformer and transmission cable	324, 000	
Total, electrical drive		$2, 509, 000
Mechanical drive:		
Rotors and shafting	$655, 000	
Two-speed gear and turning gear	237, 000	
Rotor blades and stator blades	204, 000	
Total, mechanical drive		1, 096, 000
Test section and equipment:		
Test section and supports	$660, 000	
Dynamic model research equipment	410, 000	
Total, test section and equipment		1, 070, 000
Freon system:		
Freon equipment and cooling equipment	$1, 285, 000	
Alterations to existing utilities	40, 000	
Total, Freon system		1, 325, 000
Structural work and alterations:		
Demolition	$30, 000	
Test chamber alterations and tunnel modifications	2, 320, 000	
Foundations	175, 000	
New equipment building	410, 000	
Site preparation	20, 000	
Total, structural work and alterations		2, 955, 000
Total estimated cost		8, 955, 000

High-temperature structural research laboratory

It is proposed to construct an addition to the structures research laboratory to permit research to be conducted on aircraft structural components under temperature conditions similar to those encountered in flight at supersonic speeds. The addition will include a high-heating-rate facility in which large structural models may be subjected to heat while under load. Provision will be made for controlling the rate of heat exchange to simulate actual flight conditions and provision will also be made to hold desired temperature levels for extended periods. Heating of the model will be accomplished by a combination of air discharged through a heat exchanger and directed upon the model, and radiated heat from plates mounted adjacent to the model. Structural loading of the model will be accomplished through insulated water-cooled links piercing the floors of the test cell. Special instrumentation will also be provided.

Flight speeds of piloted aircraft and guided missiles have increased to the point where the structural designer must take into account the effect of aerodynamic heating upon the strength of the aircraft.

Aerodynamic heating occurs when the thin envelope or boundary layer of air around the airplane is heated by air friction. At speeds up to M=1, aerodynamic heating, although it introduces other problems, has no effect upon structural strength. At M=2, however, the light metal alloys used in aircraft may lose some of their strength as a result of aerodynamic heating. For instance, at about M=2.5 and 35,000 feet altitude the external aluminum alloy structure would be only half as strong as it is at take-off conditions; moreover, even the strength of a stainless-steel structure would be cut in half by continuous operation at approximately M=4.2 at 35,000 feet. Inasmuch as piloted aircraft are attaining speeds in excess of M=1, and guided missiles have attained even greater speeds, the problem of structural design for aerodynamic heating is a matter of immediate concern.

Because the complex structure will be heated in a nonuniform manner, the thermal stresses will occur which may overstress part of the structure and may result in warping of aerodynamic surfaces in a manner detrimental to performance of the airplane. Continuous heating of a structure under load will cause creep, which may permanently alter critical dimensions with a detrimental effect upon aerodynamic performance. Occurrence of unanticipated hot spots may cause local damage and may even precipitate failure of the aircraft. The problems to be resolved include the behavior of metal structures during and after rapid heating to high temperatures. In the case of a long-distance aircraft, for example, a high-altitude flight plan might result in critical temperatures only while passing through the lower atmosphere. It is of particular interest to the designer to know how the transient heating affects the strength of the airplane. The effects of repeated heating cycles must also be evaluated. Another case of interest would be an airplane intended to fly at a continuous high-temperature condition. It is important to know the limiting temperatures which might be attained at various points on the structure and the length of time required to attain these temperatures. Methods of protecting the structure of the airplane, such as insulating and cooling, must also be investigated.

Existing information applicable to the problem of aerodynamic heating is sketchy. The behavior of metals at various temperatures is known from tests of material specimens, but the behavior of aircraft structures subjected to high external temperatures has not been investigated. No facilities are known in which structural models or components can be investigated under applied loads at high temperatures. Likewise, there are no facilities in which rapid heating of structural specimens can be accomplished while the specimen is under load. Without this information the designer cannot be sure that the airplane structure will be adequate in flight.

The proposed high-temperature structural research laboratory will provide a facility for the study of structural behavior under conditions similar to those created by aerodynamic heating in flight. It will be possible to install adequate structural models representing wings, fuselages or more complete airplanes and to apply loads to these models under high-heating rate and high-temperature conditions.

	Cost estimate		
Laboratory building			$320,000
High-heating-rate facility:			
Structure		$340,000	
Test cell and research equipment		1,150,000	
Thermo-accumulator system:			
Air-storage system	$185,000		
Blowers, panel control	185,000		
Accumulator housing, heating elements	1,700,000		
Electrical	143,000		
Total, thermo-accumulatory system		2,213,000	
Total, high-heating-rate facility			3,703,000
Outside utilities:			
Electrical primary supply		$110,000	
Mechanical utilities		20,000	
Total, outside utilities			130,000
Total estimated cost			4,153,000

LEWIS FLIGHT PROPULSION LABORATORY

High-pressure air supply and distribution system

Changes in the laboratory's combustion air supply and distribution system are required to make available combustion air pressures up to 125-pounds-per-square-inch gage and at quantities sufficient for full-scale engine research at various locations in the laboratory where research is being conducted on power plants for supersonic airplanes and guided missiles.

An existing 7-inch diameter combustion air line connects the present supply of 125-pounds-per-square-inch air to certain of the laboratory research facilities. The maximum capacity of the present 125-pounds-per-square-inch compressor is only about one-twentieth of that required, and the flow capacity of the present line is limited to this amount. An increase in the capacity of the system and the extension of the system to additional research facilities of the laboratory is urgently required in consideration of current research needs. Some examples of these needs follow:

In certain wind-tunnel investigations it is necessary to have a greater pressure ratio for the operation of ram-jet engines than can be obtained from the speed of the air in the wind tunnel. This requirement is also true for investigations in which the precise control of the air flow through a propulsive jet is required which is independent of the ram pressure resulting from the tunnel air speed. Another type of wind-tunnel investigation requiring an air supply at the engine under test in excess of that supplied by the tunnel is the investigation of nozzle design for various forms of jet-propulsive engines. The expanding jet from a nozzle interacts with the external boundary layer of the engine housing and with the supersonic flow field to determine the pressures over the rear portions of the housing, thereby influencing the drag of the aircraft and the effectiveness of any control surfaces located near the jet. Large models such as can be placed in the 8- by 6-foot supersonic wind tunnel are required in these investigations to obtain data at high Reynolds numbers. The proposed alterations

to the combustion air system will supply the air blast required in this wind tunnel for this research.

A third investigation requiring a large supply of compressed air in the 8- by 6-foot supersonic wind tunnel is the study of tail-pipe cooling at supersonic speeds where the cooling air flow is induced by injector action of the propulsive jet. The aerodynamic heating of bodies at supersonic speeds makes the cooling of the engine tail pipe an extremely difficult process.

Experience with jet engines in flight is demanding that the problem of deicing jet engines be further explored. The proposed alterations to the combustion air supply system will permit the extension of the icing research in the icing research tunnel to jet engine operating conditions of increased icing severity.

The researches in the use of high-energy fuel have reached the stage where the investigation of scale effects must be made. To do so requires greater capacities of combustion air in the high-energy fuel laboratories. The proposed extension of the air system will permit the testing of ram jets at superatmospheric burner inlet conditions and will permit the general speeding up of the research on the application of high-energy fuels to guided missiles.

In the field of turbine cooling, the importance of which is recognized both as a means of decreasing the use of strategic materials and as a means of increasing power output of turbo-prop engines, research is required at higher pressures and weight flows of cooling air than are now available at the laboratory. The present pressure and weight flows available in this cooling research limit the scope of the tests and consequently the speed with which the practical realization of turbine cooling can be achieved.

Cost estimate

Compressor and drive motor installed	$660, 000
After-cooler and water piping	90, 000
Machinery controls	40, 000
Piping, valves, and expansion joints at compressor	125, 000
Electrical switchgear cables, controls, and wiring	175, 000
Foundations	110, 000
Distribution piping system	367, 000
Engineering and design	75, 000
Total estimated cost	1, 642, 000

Expansion of air facilities for full-scale jet-engine research

This project consists of additional exhauster, compressor, exhaust-gas cooler, air drying and air-heater equipment, together with the necessary accessories and building to house the equipment for increasing the combustion air and exhaust gas-handling capacity of the propulsion-sciences laboratory by 50 percent of its present design capacity.

It will be necessary to construct an addition to the existing equipment building of the propulsion-sciences laboratory consisting of a bay approximately 75 feet wide by 177 feet long by 45 feet high with a 25-foot deep basement. The addition will house a four-stage exhauster system identical to the west line of the present exhauster system. Intercoolers will be located in the basement. The new exhausters will discharge into the existing stack.

The addition will also house a single motor driving two first-stage and one second-stage combustion-air compressors identical to one line

of the present compressor system. The intercooler and aftercooler will be located in the basement.

Necessary starting and running switchgear for the equipment will be installed on the main floor and a mezzanine floor in continuation of the present arrangement.

One additional air dryer tower with the necessary refrigeration equipment and accessories will be installed in the compressor bay of the existing equipment building. An additional air heater will be installed adjacent to the west wall of the equipment building and in line with the two existing heaters.

A secondary cooler will be installed in parallel with the existing secondary cooler. One additional power transformer will be required with the necessary power cable, ducts, substation additions, and accessories.

An extension of the cooling tower and the addition of pumps, vacuum deaerators and water treatment will be necessary to dissipate the added heat load.

The entire project will require 30 months for completion. However, combustion air will be available for use within 18 months after construction has begun.

It is imperative that research be conducted on full-scale jet engines under high-speed and high-altitude conditions identical to those encountered in actual flight if engines are to be provided that will be adequate for military needs. To date, the NACA has investigated in its full-scale facilities every jet engine now being utilized by the military services. Each research investigation has made significant contributions toward the development of these engines and has provided an understanding of the many new problems encountered in high-speed, high-altitude flight. Each particular engine poses many unique and unpredictable problems of component operation and interaction that can only be discovered and solved by operation of the actual engine.

The speeds and altitudes required of our military aircraft are constantly and rapidly increasing. Engine sizes and thrust capacities to provide these higher speeds and altitudes are similarly increasing. The proper and economical development of new engines and their components requires experimental investigation on full-scale models. As engines become larger the air-flow requirement of the research equipment is increased.

Another important factor in the air requirements is that as engines go faster the air-flow requirement is similarly increased. The proposed increase in air-exhaust capacity will raise the mach number limit and enable research to be conducted in the most useful range of turbojet engine applications for supersonic flight.

The proposed increase in air capacity of the propulsion-sciences laboratory is needed to permit the NACA to continue the research that has been in progress during the past 8 years on full-scale jet engines. This research will be directed toward studies resulting in increasing the efficiency of combustors, tail-pipe burners, compressors, diffusers, turbines, and in improving the operational limits of the complete engine. Combustion research under altitude conditions is vitally needed to obtain the large potential gains in aircraft range through improved combustion efficiency and to raise present ceilings on operational altitudes imposed by combustion blow-out. Automatic control

systems research is required because of increasing complexity of manual engine operation and the need to automatically maintain engine operation at optimum conditions for maximum fuel economy, thrust output, and life. While current types of piloted aircraft place a high emphasis on good control systems, the coming era of pilotless missiles will require completely automatic methods of control. Basic research on the problems of compressor surge and the transient behavior of combustor blow-out is needed on actual full-scale engines at altitude conditions to provide information for these control systems.

The modernization and continued expansion of propulsion research facilities must keep pace with the performance and operational characteristics of advanced propulsion units to insure continued leadership in the air. Engine manufacturers and the military services require accurate and detailed data on the performance and operational characteristics of their engines. The problems involved in supplying these data can be discovered, evaluated, and solved in full-scale research facilities without the extensive and costly modifications that would be required in attempting to accomplish this work by means of hazardous flight investigations. The expansion of the air facilities proposed for the propulsion sciences laboratory will be a vital factor in providing for continued acceleration of engine development.

	Cost estimate
Exhaust system	$1, 505, 000
Compressor system	695, 000
Secondary exhaust gas cooler	230, 000
Air heater	135, 000
Air dryer	285, 000
Piping and controls	550, 000
Cooling tower, pumps, and water treatment	318, 000
Addition to equipment building	550, 000
Transformers, substations, cables, and switchgear	582, 000
Engineering design	100, 000
Total estimated cost	4, 950, 000

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